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THE EFFECTS OF INSTRUCTIONS, CONCEPT COMPLEXITY, METHOD OF PRESENTATION, AND ORDER OF CONCEPTS UPON A CONCEPT ATTAINMENT TASK.

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*CONCEPT FORMATION, LEARNING PROCESSES, CONCEPT TEACHING, FUNDAMENTAL CONCEPTS, *SEX DIFFERENCES, *COLLEGE STUDENTS, *PERFORMANCE FACTORS, PERFORMANCE, TASK PERFORMANCE, *RESEARCH AND DEVELOPMENT CENTERS, MADISON, WISCONSIN

AN EXPERIMENT WAS CONDUCTED TO DETERMINE THE FUNCTIONAL RELATIONSHIPS BETWEEN SUCH VARIABLES AS TYPE OF MATERIAL, NUMBER OF RELEVANT ATTRIBUTES, AND PERFORMANCE OF A PERSON ATTAINING CONCEPTS. CONCEPT ATTAINMENT BOARDS OF THE BRUNER (1956) TYPE WERE USED, AND VARIOUS PARAMETERS CONTAINED IN THE BOARDS WERE MANIPULATED. THE NUMBER OF RELEVANT AND IRRELEVANT ATTRIBUTES IN A CONCEPT WAS VARIED. INSTRUCTION, THE TYPE OF PROBLEM, PROBLEM ORDER, AND THE TYPE OF BOARD (FIGURAL OR VERBAL) WERE ALSO TREATED AS VARIABLES. INSTRUCTIONS FOR THE TASK WERE EITHER GIVEN TO THE 64 FEMALE AND 48 MALE SUBJECTS BY A TAPE RECORDING OR FROM A BOOKLET. FOUR DISTINCT SEQUENCES OF CONCEPTS WERE DEVELOPED AND EACH SEQUENCE WAS USED WITH SIX MALES AND EIGHT FEMALES. THE DEPENDENT VARIABLES WERE TIME-TO-CRITERION AND NUMBER OF CARD CHOICES. RESULTS FROM THE VERBAL CONCEPTS SHOWED THAT SEX, INSTRUCTIONS, AND CONCEPT ORDER HAD NO SIGNIFICANT EFFECT. THE J-2 CONCEPTS (COMBINATIONS OF TWO) WERE EASIER THAN THE J-3, (COMBINATIONS OF THREE) AND RECEPTION CONCEPTS WERE EASIER THAN SELECTION CONCEPTS. ON THE TWO TRAINING CONCEPTS, THE J-3 CONCEPT WAS EASIER THAN THE J-2 BOTH IN TERMS OF TIME AND NUMBER OF CARD CHOICES. IT WAS HYPOTHESIZED THAT UNUSUAL RESULTS OBTAINED FROM THE FIGURAL BOARD CONCEPT WERE DUE TO THE SALIENCE LEVELS OF THE ATTRIBUTES. IT WAS FURTHER HYPOTHESIZED THAT ANY ANALYSIS OF CONCEPT MUST CONSIDER NUMBER OF RELEVANT AND IRRELEVANT ATTRIBUTES AND THE SALIENCE LEVEL. (JC)

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Technical Report No. 3

THE EFFECTS OF INSTRUCTIONS, CONCEPT COMPLEXITY, METHOD OF PRESENTATION, AND ORDER OF CONCEPTS UPON A CONCEPT ATTAINMENT TASK

By Wayne C. Fredrick

Based on a master's thesis under the direction of

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Research and Development Center

for Learning and Re-Education

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PREFACE

This technical report is based on the master's thesis of Wayne C. Fredrick. Thesis committee members were Herbert J. Klausmeier, Chairman; Chester W. Harris; and Thomas J. Johnson.

In our programmatic research on concept attainment in the R & D Center we have developed a taxonomy of variables in concept attainment and are ascertaining functional relationships among the variables. The three main classes of manipulable variables are associated with the stimulus material, instructions used in the experiment, and response modes. Organismic variables deal with the subjects, or students, and are usually treated as stratifying variables. Conditions of learning such as motivation and practice are also included in the taxonomy. (See Technical Report No. 1 for the entire listing.)

In this study Mr. Fredrick has drawn subvariables from three main classes—stimulus, instructions, and organismic. A most important conclusion in this study was that the number of relevant attributes comprising the concept, the number that are irrelevant, and the salience level of the attributes affect efficiency of attaining the concept. The results here and in other studies indicate that these may be important variables to be considered in writing instructional material that is intended to teach concepts. We are extending knowledge of these laboratory-based conclusions through experiments with instructional material used in the schools.

Herbert J. Klausmeier
Co-Director for Research

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TABLE OF CONTENTS

		Page
	List of Tables and Figures	vii
	Abstract	ix
I	INTRODUCTION	1
	The Problem	1
	Subjects, Materials, Design	1
	Procedure	2
II	Review of the Literature	4
	Sex Differences in Concept Learning	4
	Number of Relevant and Irrelevant Attributes	4
	Concept Salience	6
	Method of Concept Presentation	7
	Summary and Conclusions	8
III	Results	10
IV	Discussion	14
	Question 1 - Instructions	14
	Question 2 - Sex of Subject	14
	Question 3 - Relevant and Irrelevant Attributes	15
	Question 4 - Reception and Selection Concepts	17
	Question 5 - Salience	17
	Question 6 - Transfer	18
	Concluding Discussion and Final Summary	19
	Appendix	21
	References	25

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LIST OF TABLES AND FIGURES

Table 1 ANOVA Table of Mean Squares, Degrees of Freedom and F Ratios for Five Independent Variables on Times-to-Criterion of Four Concepts on a Verbal Board . . . . . Page 11

Table 2 Summary Table of Mean Times-to-criterion and Méan Numbers of Card Choices for the Indicated Groups. 13

Figure 1 Card #42 from the Figural Board and Card #65 from the Ed Psych Board 1

Figure 2 Average Times-to-criterion for the Four Test Concepts. 12

Figure 3 Average Times-to-criterion on Each of the Two Training Concepts for Males and Females. 13

Figure 4 Difficulty as a Function of Number of Relevant and Irrelevant Attributes 16

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ABSTRACT

Forty-eight males and 64 females working individually attained two training concepts on a figural board and then four concepts on a verbal board. The boards had on them 64 cards in an ordered arrangement and were much like those used by Bruner et al. (1956). Concepts were combinations of two (J-2) or three (J-3) of the attribute values on the board. Two of the four concepts attained via the verbal board were of the same form as the two training concepts on the figural board, namely, the S had to choose cards to find which cards did or did not belong to the concept. The concepts in which Ss had to choose cards were called selection concepts. The other two concepts of the verbal board were called reception concepts since, in these, three or four YES and NO cards were marked and the S then attained the concept from these marked cards.

The instructions for the task were either given to the Ss by a tape recording or the Ss read them from a booklet. Four distinct sequences of concepts were developed and each sequence was used with six males and eight females.

The independent variables were: male or female; J-2 or J-3; selection or reception; J-2, J-3 or J-3, J-2; training, selection, reception or training, reception, selection; and taped instructions or written instructions. The dependent variables were time-to-criterion and number of card choices.

The results obtained from the verbal concepts showed that sex, instructions, and concept order had no significant effect. The J-2 concepts were easier than the J-3, and the reception concepts were much easier than the selection concepts. Ss improved from the first concept to the second in the set of two selection concepts and in the set of two reception concepts.

On the two training concepts, however, the J-3 concept was easier than the J-2 both in terms of time and number of card choices. The J-value interacted with the sex of the S, and females made more card choices than males. It was hypothesized that the unusual results obtained from the figural board concepts were due to the salience levels of the attributes. SOLID BORDERS, GREEN CIRCLES was a more salient concept than ONE LARGE, and females used this salience more than males did.

It was further hypothesized that any analysis of a concept must consider number of relevant attributes, number of irrelevant attributes, and salience level of the attributes.

I
INTRODUCTION

THE PROBLEM

It was the purpose of this experiment to determine the functional relationships between variables, such as type of material and number of relevant attributes, and the performance of a person attaining concepts. Concept attainment boards of the Bruner (1956) type were used, and various parameters contained in the boards were manipulated. The number of relevant and irrelevant attributes in a concept was varied. Instructions, the type of problem (selection or reception), the order of problems, and the type of board (figural or verbal) were also treated as variables.

The specific questions which this experiment attempted to answer are the following:

1. Is there a difference in performance between hearing the instructions for the task or reading them ?
2. Is there a difference in performance between males and females on this concept attainment task ?
3. Are concepts with three relevant attributes (J-3) more difficult to attain than concepts with two relevant attributes (J-2) ?
4. Will a concept for which minimal but sufficient information is given (reception) be easier to attain than a concept for which the subject (S) must obtain information for himself (selection) ?
5. What is the effect of the dominance or "salience" level of certain attributes ?
6. Will practice on one type of concept aid in the attainment of another ? (Does practice in attaining concepts on a figural board transfer positively or negatively to a verbal board ? Will J-3 concepts provide skills which can be applied to J-2 concepts and vice-versa ? Will the reception task provide skills which can be put to use in the selection task and vice-versa ?)

SUBJECTS, MATERIALS, DESIGN

The Ss were 64 females and 48 males who were taking a 1963 summer session course in educational psychology. The ages of the Ss ranged from 20 years to 34 years. The mean age was 23.4 years and the model age was 22 years. More females than males were used because there were more females in the course.

The materials used were two 64 card concept attainment boards. One board contained figural material (figural board), and the other contained verbal material (Ed Psych board). Each board had six attributes and each attribute had two values. Fig. 1 shows an example of a card from each board.

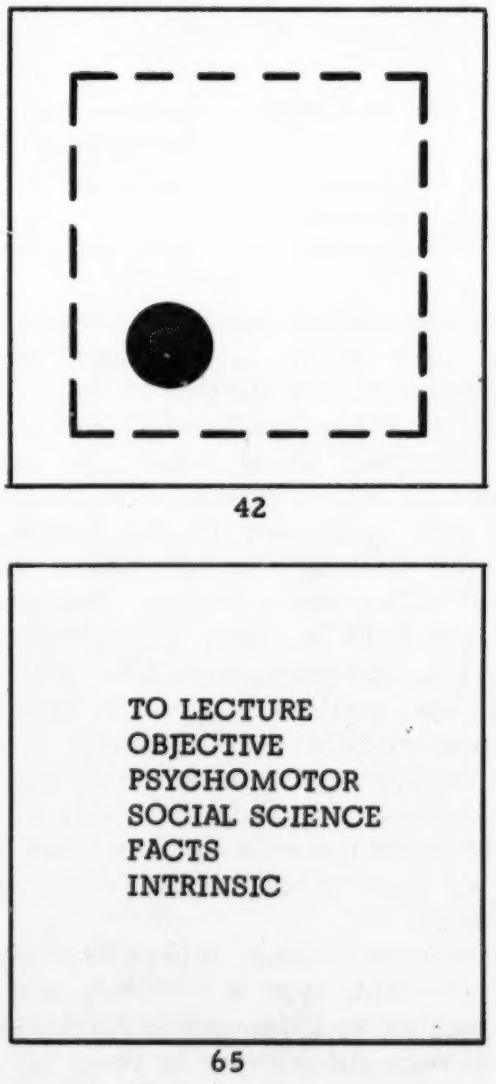

Fig. 1 Card #42 from the figural board and card #65 from the Ed Psych board.

The 64 cards for each board were randomly numbered and then arranged on the board in eight rows and eight columns. In addition to the spatial order, the cards were systematically placed so that cards within any row had three attribute values in common, and also the cards within a column had three attribute values in common.

The attributes and values of each board are given below.

Board	Attribute	Values	
Figural	Color of figure	Red	Green
	Size of figure	Large	Small
	Shape of figure	Circle	Ellipse
	Number of figures	One	Two
	Continuity of borders	Solid	Broken
	Number of borders	One	Two
Ed Psych	Teacher Method	To Lecture	To Demonstrate
	Evaluation	Objective	Subjective
	Domain	Cognitive	Psychomotor
	Subject Area	Natural Science	Social Science
	Learning Outcome	Facts	Motor Skills
	Motivation	Extrinsic	Intrinsic

The Ss attained two training concepts of the selection type on the figural board, and then four concepts on the verbal Ed Psych board. In two of the last four concepts, S had to select cards (selection), while in the other two concept tasks all information needed to attain the concept was presented to the S (reception). Each of the training concepts had a 12 minute time limit. The two selection concepts were also limited to 12 minutes, and the other two, the reception concepts, were limited to 7 minutes. Ss who could not attain at least one of the training concepts were excused. The data from the excused Ss were not used and new Ss were brought in to replace the excused Ss. Any S who could not attain at least one of each of the two sets of test concepts was excused and replaced.

Type of instructions, difficulty of concept, order of concept, type of concept, and sex of S were treated as independent variables. Instructions were either heard by the S via a tape recorder or read by the S from an instruction booklet. The concepts had either two (J-2) or three (J-3) relevant attributes (correspondingly either four or three irrelevant attributes) and were selection or reception.

There were four different sequences of concepts. The treatment for a S in Sequence 1 was as follows:

A. Instructions for figural board
B. J-2 training concept
C. J-3 training concept
D. Instructions for verbal board
E. Instructions for selection concepts
F. J-2 selection concept
G. J-3 selection concept
H. Instructions for reception concepts
I. J-2 reception concept
J. J-3 reception concept

For Sequence 2: ACBDEGFHJI, 3: ABCDHIJEFG, and 4: ACBDHJIEGF. In each sequence there were six males and eight females run one at a time with written instructions. The same numbers were run one S at a time with taped instructions. The instructions are given in detail in the appendix.

PROCEDURE

Each S had to attain two concepts on the figural board. These were the training concepts. One concept was ONE LARGE FIGURE. The other was SOLID BORDER, GREEN CIRCLE. In the former concept only two attributes were relevant, number and size of the figures, and this was called the J-2 concept. The latter was a J-3 concept since border continuity and color and shape of figures were relevant.

The concepts for the two selection tasks on the Ed Psych board were OBJECTIVE, COGNITIVE (J-2) and TO DEMONSTRATE, COGNITIVE, FACTS (J-3).

In the two training tasks and the selection tasks the S was given a focus card, which the S knew to be an exemplar of the concept. The S had to pick other cards to find exactly what the concept was. After a card choice the E said "Yes" if the card was part of the concept, "No" if it wasn't. The E timed the S on each concept and serially recorded card choices and hypothesized concepts offered. The S worked until he attained the concept or until the 12 minute limit. Concepts were attained when the S had correctly marked all the relevant attribute values on a slip of paper.

The two reception concepts were PSYCHOMOTOR, MOTOR SKILLS (J-2) and TO DEMONSTRATE, COGNITIVE, INTRINSIC (J-3). For each concept, information in the form of "no" and "yes" cards sufficient to attain the concept was given the S. The E recorded the concepts

offered by the S until solution or the seven-minute time limit was reached. The entire experiment took 25 to 60 minutes depending on the speed and ability of the S.

Males and females were randomly assigned to instructions and sequences with the restriction there be six males and eight females in each sequence. The sequences were randomly run so that effects such as experimenter improvement or possible grapevine feedback would be randomized. The five Es were assigned Ss so that possible interaction was randomized or equalized across instructions, sex, and sequence.

The number of card choices and time to solution were obtained as dependent variables. Analysis of variance (ANOVA) F ratios and t tests were used to compare means.

II
REVIEW OF THE LITERATURE

In this chapter, experiments in concept learning which have studied sex differences, concept complexity, salience of attributes, and methods of presentation are reviewed. The facilities of the Research and Development Center for Learning and Re-Education were used to compile the review. Experiments which give the reader an overview, and provide a context of results based on independent variables which are similar to those of the present study are included. (The significance level referred to is .05 or beyond.)

SEX DIFFERENCES IN CONCEPT LEARNING

The sex of the subject has usually been an insignificant variable in concept attainment studies (Pishkin, 1960; Conant & Trabasso, 1964; Olson, 1963; Klausmeier, Harris & Wiersma, 1964; Klausmeier, 1964; Rasmussen & Archer, 1961; Tagatz, 1963). However, an experiment by Pishkin and Blanchard (1964) in which auditory stimuli varied on five dimensions, did find differential ability for males and females. Males made significantly more errors than females if the concept involved laterality (presentation of the stimulus complex into left or right earphones) as a relevant dimension.

Other studies have found that the sex of the subject interacting with type of concept to be attained sometimes results in differences. Olson (1963) saw that high school boys attained the concept of a lever significantly faster than girls, but were equal to girls on the concepts of reciprocating motion, multiples-of-three, and alphabetical order. Sixth grade boys persevered significantly longer than did girls when trying to solve a Luchins' water jar problem, but not when solving other problems (Ackerman & Levin, 1958).

Archer (1962) tested the hypothesis that when the attention of a S is drawn to irrelevant information, he will try to use it to solve the concept problem. Archer manipulated the obviousness of the size dimension and the form dimension. At both high and low levels of obviousness men found concepts based on form easy to attain but difficult when form was irrelevant. Women experienced just the opposite. If form was relevant, the problem was harder for females than when form was irrelevant. This difference between men and women on the form dimension was significant at the .05 level for time-to-criterion, and nearly significant for errors-to-criterion measures. Pishkin (1960) did not find this difference. In the present experiment form is irrelevant on one training concept and relevant on the other, while size is reversed.

NUMBER OF RELEVANT AND IRRELEVANT ATTRIBUTES

This area has received considerable research and in general the findings have shown that concept attainment becomes more difficult as both relevant and irrelevant attributes increase in number. The unanimity of results allows one to use number of relevant attributes as a measure of the complexity of a concept. Concept complexity seems to be roughly equal to the amount of information contained in the concept. With two valued attributes, which were used in the present experiment and the majority of those cited, each relevant attribute adds one bit of information to the concept and thereby increases its complexity. Irrelevant attributes add a different complicating aspect. Each additional irrelevant attribute adds a bit of "noise," thereby making it harder to find and use the relevant attributes. Studies dealing with number of irrelevant attributes follow immediately.

Gregg (1954) and Archer (1954) had Ss classify one or more binary relevant dimensions while ignoring one or more binary irrelevant dimensions. Gregg found a small but significant linear increase in reaction time as the number of irrelevant dimensions was increased from one to three. In Archer's study, the addition of two irrelevant dimensions to the visual patterns did not increase reaction time.

Subsequent studies have looked more closely at the effect which the number of relevant and irrelevant attributes have on a concept attainment task. The general procedure of the Archer experiments is as follows: Ss sit before a response board which has four finger keys or response buttons. Geometric patterns having from three to seven two-valued attributes are presented on an oscilloscope or by a projector. The S must learn to classify each pattern that appears by pressing the correct button. Concepts are conjunctive combinations of two of the attributes. If, for example, form and color were the relevant attributes, the S would have to learn to press button A for red triangles, B for blue triangles, C for red squares, and D for blue squares. The Ss are run to a criterion of 32 correct consecutive responses. The tasks are paced by the S, who gets feedback and knows the nature of the concepts to be learned.

Using this general procedure, Archer, Bourne, and Brown (1955) found that performance in concept identification was degraded as a positive exponential function of amount of irrelevant information measured in bits. As irrelevant information increased from one to five bits, both time needed and errors increased exponentially.

In a slightly different arrangement using 16 geometric patterns projected on a screen, the number of correct responses was found to be an inverse linear function of the task complexity as measured in bits of irrelevant information (Brown & Archer, 1956).

Bourne (1957) showed that the error rate of a S learning to press the correct one of four finger keys in response to two attribute geometric concepts was a linearly increasing function of the amount of irrelevant information. This result was again obtained in a later study (Bourne & Haygood, 1960).

The effect of irrelevant information in depressing the rate of concept identification was consistently found using the finger key arrangement (Rasmussen & Archer, 1961; Archer, 1962; Bourne & Bunderson, 1963; Haygood & Bourne, 1964).

Other experimenters have obtained results similar to the above. Johannsen (1962), who was studying feedback, noted the effect of irrelevant dimensions on task complexity. The stimuli were geometric figures varying on seven dimensions, one of which was always relevant. Either one, three, or six dimensions were irrelevant. S had to press one of two telegraph keys to indicate his response. Significant at the .01 level was the amount of irrelevant information. Increasing the number of irrelevant dimensions decreased the number of correct responses.

Pishkin and Blanchard (1964) used auditory stimuli varying on five dimensions. As the number of irrelevant dimensions increased from one to three, with one dimension always relevant, the number of errors increased significantly.

Pishkin (1960) previously had worked with geometric patterns in which one of either form, size, or number was always relevant, and either one, three, or five dimensions were irrelevant. Ss had to press one of two keys according to the relevant dimension. Misinformation and complexity (the number of irrelevant dimensions) were both significant, as was the interaction of the two. Errors increased as the number of irrelevant dimensions increased. Misinformation inhibited concept identification more at higher levels of complexity than at lower levels.

Meyer and Offenbach (1962) had 270 third and fourth graders participate in a discrimination task. Position of the blocks was always the relevant attribute. Color, shape, and height of the blocks were irrelevant variables. Series I problems contained only one of the irrelevant dimensions; Series II had two irrelevant; and in Series III, all three of the irrelevant dimensions were included. Trials-to-criterion was the dependent variable. For all schedules of reinforcement the Series I problems required fewer trials than II and III. (II and III were not significantly different.)

In an experiment using combinations of three levels of irrelevant information and three levels of relevant, Walker and Bourne (1961) found a linear decrement in performance with increased irrelevant information, and an exponential decrement with increased relevant information.

The following paragraphs of this section deal with the effect of the number of relevant attributes upon concept learning.

Bulgarella and Archer (1962) varied bits of relevant and irrelevant information in an experiment using auditory stimuli. Trials-to-criterion, number of errors, and time-to-criterion showed both relevant and irrelevant information significant at the .001 level. The interaction of the two was not significant. Specifically, the difficulty of the problem, measured by the three dependent variables, increased as the number of relevant attributes increased from one to two to three, and as the number of irrelevant attributes increased from zero to one to two.

Bourne (1963) found a similar increase in difficulty as the number of relevant dimensions of figural material increased from one to three.

Neisser and Weene (1962) tested concepts

which they called "hierarchically organized." Actually the concepts were based on the absence or presence of one or two of five letters. Those concepts based on two letters took significantly longer to attain than those based on only one letter. This again is an example of additional relevant information increasing concept difficulty.

Peterson (1962) used 6 three-valued figural dimensions in a concept task. As the percent of the values which were relevant increased, the difficulty of the concepts increased significantly.

Johnson, Lincoln, and Hall (1961) worked with verbal problem-solving tasks. Ss were to find a solution that would meet specifications which were stated as discrete items. Flat, readable, descriptive, and gummed would specify "label." The number of specifications (from three to eleven) was used as the independent variable. As this number increased, preparation time also increased from 5 to 15 seconds.

Shepard, Hovland, and Jenkins (1961) and Posner (1964) have clarified and unified many of the results regarding the number of relevant dimensions by defining a quantity common to all the studies. This quantity is the amount of information reduced. An example based on the Bruner-type concept boards will serve to explain information reduced. Suppose the concept ONE LARGE has been learned. For the learner to decide whether a certain card is part of the concept he must note that it contains ONE, and not TWO, and LARGE, not SMALL. In other words he processes two pieces of information in order to classify each card. If the concept were ONE LARGE CIRCLE, the learner would need to process three pieces of information to determine group membership of a card. In any concept, Shepard et al. argued, there is implicit a grouping of several pieces or bits of information. As more and more bits of information are grouped, the information load of a concept increases. This information reduced is a measure of the difficulty with which a concept can be learned and applied.

Shepard, Hovland, and Jenkins (1961) had done a very sophisticated experiment which showed the correctness of their generalization. They used three binary dimensions which made a set of eight stimuli. These stimuli were used to make special categories for a series of problems. For some categories only one dimension was relevant, for others two dimensions or two and one-half or three. In this way the information within a response category could be calculated. In other words, the amount of information reduced was obtained. Shepard et al. found a linear relation between rate of concept learning and the information reduced in obtaining the binary classification. As information to be reduced (relevant dimensions) increased, the rate of learning decreased.

Wallach (1962) reasoned that concepts are acquired by unitizing several cognitive units, and the difficulty of unitizing depends on the number of units to be combined and the structure in which they are to unite. She tested this hypothesis on 60 students who were to attain concepts embedded in three pairs of curved lines. Three types of concepts were made. One type consisted of only one pair of curved lines determining the concept. A second type of concept was based on a certain arrangement of two pairs of lines and the third type was based on all three pairs. The types are thus very similar to those developed by Shepard et al. (1961), and the same analysis applies. Wallach added the additional complexity of having half her Ss attain the concept when the three pairs of lines were connected to make a single design.

The Type I concepts in which only one pair of lines was relevant required fewer trials to be learned than the Type II and III, which did not differ. When the connected pairs were tested, the types did not differ. All the connected pairs concepts were harder than the Type I separated pairs, but were easier than the Type III separated pairs. These results supported Wallach's contention that not only are objective attributes to be considered, but also the subjective cognitive units. The "Cognitive Units" may be quite relevant to concept learning experiments which use compact geometric figures containing the attributes.

CONCEPT SALIENCE

Under this heading experiments which test the obviousness of certain attributes, the dominance of one type of concept over another, and the dominance level of attributes, will be discussed. The term "salience" refers to the phenomenon of a conspicuous property of the attributes of the concept causing the concept to be attained more readily than similar concepts.

Hull (1920) obtained early experimental evidence of salience. He had human Ss learn twelve series of twelve Chinese pictograph symbols paired with nonsense syllables. The same twelve radicals (Chinese word symbols analogous to English word stems) were paired with the same nonsense syllable in each of the

twelve series, but this was not known by the S. The radicals had additional irrelevant parts. If Hull made the radical more noticeable by making it a distinctive color, the task was easier, and even more so with few irrelevant elements. (Hull also foreshadowed the results of experiments in the previous sections when he found that those concepts which had fewer irrelevant aspects were easier to learn than those in which much irrelevant information was included.)

Edna Heidbreder (1948) noted the salience of particular types of concepts. She had Ss sort into piles packs of cards which had on them line drawings of concrete objects, geometrical forms, and numbers of things. When Ss were instructed to sort a pack of cards into three piles, the number pack took longer to sort than the geometrical form pack which in turn took longer than the concrete object pack. When other Ss were to sort all three packs into nine piles the object classes were used most often, the form classes next most, and the number classes least of the three. This order of ease of attainment was found in the majority of Heidbreder's studies, and she attributed this to the perceptual qualities of the concepts. She argued that because of organismic factors, categorization becomes harder as you go from perceptual concepts to more conceptual ones. If Heidbreder's generalization is adequate it implies that in the present experiment the concepts on the verbal board will be harder than those on the figural board.

Other experimenters have disputed Heidbreder's explanation of why object concepts are easier than form concepts and why form concepts are easier than number concepts, but the order of attainment has been replicated often (Wenzel & Flurry, 1948; Baum, 1954).

Archer (1962) took a brief look at the effect that making relevant and irrelevant attributes more obvious or less obvious would have on time-to-criterion and errors-to-criterion. For one group, form differences were relevant and obvious, and for another form differences were irrelevant and obvious. Two other groups had form differences not as obvious, but size differences were obvious and either relevant or irrelevant. Concepts based on size were easier to solve than those based on form, and there was an interaction of obviousness with relevance ($p < .01$). When the relevant dimension was obvious the problem was easy, but when an irrelevant dimension was obvious the problem took longer and Ss made more errors.

E. B. Hunt (1961) noted in a memory experiment that Ss have biases toward using particular dimensions. Wallace has studied this further and has shown that Ss are also biased toward some concepts more than others.

Wallace (1964) has studied the dominance of concepts consisting of geometric patterns. He obtained dominance measures of two-attribute conjunctive concepts by having 50 Ss list concepts. First mentioned concept, order of emission of concepts, frequency of emission of certain concepts, and most frequently omitted concepts determined the dominance level. Color-form concepts were high in dominance and number-color concepts were low. Wallace then had other Ss attain concepts which were high and low dominant. Ss attaining high dominance concepts needed fewer instances to solution than those attaining low dominance concepts. Dominance interacted with feedback intensity. With strong feedback intensity low dominance concepts were attained with fewer instances than at weak intensity. High dominance concepts required more instances at high intensity than at low. Wallace suggested that possibly the strong feedback disrupts initial dominance levels, and Ss can then shift more readily from available concept responses to more remote ones.

METHOD OF CONCEPT PRESENTATION

In several studies a test was made of the most efficient way of having Ss learn concepts. Bourne and Parker (1964) noted the prudence of using a compact array as was done in this experiment. Their conclusion was that if the concept task is the discovery of a rule for classifying stimulus patterns, the use of compact displays eliminates most of the adverse perceptual and memory requirements. Robert V. Seymour (1954, in Bruner et al., 1956) showed that an ordered array permits more efficient concept learning than a random array. Ss made fewer card choices, fewer redundant choices, and gave better hypotheses with the ordered array.

Johnson and O'Reilly (1964) have shown that Ss learning concepts from verbal arrangements give better classifications and definitions than those working on a pictorial arrangement of the verbal attributes. They conclude that isolated verbal phrases have less irrelevant features than an organized figure and that the figure is consequently more difficult to analyze. Nevertheless, Ss working first with the figural material showed positive transfer on the verbal material, and so did Ss going from verbal to figural.

Ramsay (1965) in a task similar to that of

the present study tested figural and verbal material. The time-to-criterion for attaining concepts from a figural board was significantly less than the time required on a verbal board. This result was true for both individuals and pairs, and was highly reliable ($p < .01$).

Several people have tested the efficiency of various types of concept presentation which were similar to the selection and reception concepts listed in this experiment. Huttenlocher (1962) showed that Ss who selected their own information (the Ss set up a series of black and white blocks themselves to see if the reinforcement light would go on) when learning concepts did more poorly than Ss who later reasoned from their results. Manipulation or selecting test examples added a complicating factor. It seems that making decisions about attributes to be checked results in slower concept learning.

Kates and Yudin (1964) tested three methods of presentation, simultaneous, successive, and focus. In simultaneous presentation, each new instance and all previous instances are constantly in view. In successive presentation only the new instance is in view, and in focus presentation the new instance and the focus card are in view. Simultaneous presentation seems analogous to a reception-type concept in which all cards of interest are clearly marked and displayed. Successive and focus presentation are more similar to a selection-type concept. At any rate, Kates and Yudin found that the simultaneous condition resulted in more and better solutions than the successive or focus conditions. This they felt was due to the greater memory requirements of the successive and focus conditions.

Hovland and Weiss (1953) had also shown the simultaneous method superior to the successive. A similar result was obtained by Bourne (1963).

Cahill and Hovland (1960) looked at the type of errors made under conditions of simultaneous and successive presentations. Perceptual inference errors were infrequent, and no reliable difference between methods of presentation was found in regard to these. Memory errors, those in which the S failed to recall earlier presented instances, did show a reliable difference ($p < .001$). Ss in the successive condition failed to utilize progressively more instances as the number of instances increased. Those Ss who made more perceptual-inference and memory errors had greater difficulty in acquiring the concepts.

A study by Klausmeier, Wiersma, and Harris (1963) bears directly upon the transfer that may be expected in this type of task. Individuals working a series of J-2 concepts on a 128-card ordered figural board improved significantly from the first concept to the fifth concept. When 12 minutes of interpolated activity preceded the fifth concept, there was still positive transfer but not as much as when the fifth concept immediately followed the others.

SUMMARY AND CONCLUSIONS

The sex of the concept learner does not usually interact with concept attainment. Males and females do about equally well in most of the experiments. Archer (1962) came across an interesting situation in which men could attain concepts more easily than women when form was relevant. Women, in turn, could attain the concept more quickly than men when form was irrelevant. Archer hypothesized that this was due to the males having the names of the forms closer at hand than females. But this hypothesis is suspect when one remembers that females usually score higher than males on verbal fluency (Terman and Tyler, 1954; Tyler, 1956).

The present experiment compares 64 females to 48 males on the attainment of a series of six concepts. The two training concepts on the figural board should give results which relate to the Archer hypothesis since form is relevant in one concept and irrelevant in the other. The other four concepts deal with verbal material and should be of interest in terms of the Archer result and in determining relative efficiency of males and females.

The effect of irrelevant information has been extensively studied. Increasing irrelevant attributes has consistently produced slower learning and more errors by the S. This effect has held across many types of materials and tasks. Relevant information shows somewhat the same effect as irrelevant. As the number of relevant attributes is increased the difficulty of the concept also increases. Shepard, Hovland, and Jenkins (1961) have shown how "information reduced" is the quantity which is common to all these concept tasks. As yet the interaction of relevant and irrelevant information has not been tested widely.

Attribute and concept dominance can have an effect upon the attainment of a concept. Since Hull in 1920 showed that highlighting the relevant parts of a concept exemplar could cause faster learning of that concept, experimenters have only slowly come to realize that inherent properties of their stimulus materials have an effect that wasn't considered. Though,

objectively, the "information reduced" may be equal for two concepts, one concept may still be learned faster than another because of some subjective effect of the attributes making up the concept. From the work of Heidbreder (1948), for example, it appears that form is an easier attribute to work with than number. Archer's (1962) study on obviousness of attributes shows that increasing or decreasing discriminability along a dimension affects the Ss choice of attributes to test. Wallace (1964) goes further and shows that various attributes of a figural array are at subjectively different levels of dominance even before their obviousness is manipulated.

In the present study the two training concepts are ONE LARGE FIGURE and SOLID BORDERS, GREEN CIRCLES. All else being equal, the results regarding salience might lead one to conclude that the concept involving color-form will have a higher salience level than the one involving number-size, and hence will be easier. If this should occur it will be very interesting since then the J-3 concept will be easier than the J-2 despite the additional bit of "information reduced."

When considering the method of presentation, the memory requirements of a task seem to be an important consideration. Concept learning becomes difficult when the S must remember previous instances. The present experiment has two types of tasks which differ in the requirements made of the S. In the reception concepts there is no need to remember card choices as in the selection concepts, and it is expected that time to criterion will reflect this difference.

Other aspects of presentation methods must be controlled. Compact, ordered arrays eliminate many variables inherent in random displays. Whether figural or verbal materials are more proper to use in studying concept attainment is a moot question.

Skills learned in one concept task may transfer to another concept. The present experiment, in which two types of materials (figural and verbal), two types of tasks (reception and selection), and two types of concepts (J-2 and J-3) are used, will yield results pertinent to transfer of skills.

III
RESULTS

The times-to-criterion on the four test concepts were analyzed by a five-way analysis of variance (ANOVA). The five variables were the two types of instructions (tape recorded and written), two orders of concept type (selection, reception and reception, selection), two orders of concept complexity (J-2, J-3 and J-3, J-2), two concept types (selection and reception), and two concept complexity levels (J-2 and J-3).

Comparisons of the mean times on the training concepts were tested for significance with t tests. Comparisons of number of card choices were also tested for significance with t tests.

The ANOVA of the times-to-criterion on the four test concepts showed that two main effects and two first order interactions yielded significant F ratios. Type of concept was significant at the .001 level. The average time it took Ss to attain a selection concept was 5.5 minutes, and the average time for a reception concept was 2.1 minutes. The J-value of a concept was the other significant main effect. J-2 concepts were attained in 3.1 minutes and the J-3 concepts required an average of 4.4 minutes. The probability of obtaining this result by chance was less than .01. The ANOVA is summarized in Table 1 and the F ratios are given.

The concepts attained by Ss who received written instructions were attained an average of about .3 minutes before those of Ss who received taped instructions, but this difference was not significant. The effects of order of type of concept had no significant main effect nor did the order of difficulty of concept have a main effect.

Sex of S, which was tested in a separate analysis of time-to-criterion, did not appreciably affect the concept attainment time of the test concepts. Males needed slightly more time on the average (3.84 minutes as compared to 3.72 minutes for females), but this was far from significant.

The two interactions that gave significant F ratios were order of difficulty by difficulty, and difficulty by concept type. The first was significant at the .01 level and the second at the .05 level. The means for the concepts when separated into groups according to order of difficulty and difficulty are shown in Figure 2. Note that the J-2 concepts took less time than the J-3 concepts in the corresponding positions. The interaction of order of difficulty by difficulty is a sequence effect; the Ss improved significantly from the first concept to the second in each set of two selection and two reception concepts.

The interaction of difficulty by problem type is shown in Figure 2. J-3 concepts take more time as the main significant effect of difficulty shows, and selection concepts take more time as the main significant effect of concept type shows. From the interaction of difficulty with concept type we see that J-3 selection concepts are relatively more difficult in comparison with J-2 selection than J-3 reception are in comparison with J-2 reception concepts.

No other first order interactions were significant, nor were any higher order interactions significant.

The numbers of card choices made by Ss on the training and selection concepts were also considered. Males chose an average of 17.4 cards on each of the training and selection concepts. Females chose 15.0 cards on the average. This difference resulted in a t test value of 2.23, which was significant at the .05 level.

The interpolation of reception concepts between the training and selection concepts had an effect on the number of card choices. If the selection tasks immediately followed the training concepts, the Ss needed 12.9 card choices to attain each selection concept. In Sequences 3 and 4 where the reception concepts came before the selection, the Ss used 15.5 card choices. This difference was significant at the .05 level ($t = 2.25$).

The effect of instructions on number of card choices was not significant. The mean numbers were 16.1 card choices for Ss receiving taped instructions and 15.9 for those receiving written. J-value was also not significant; J-3 con-

TABLE 1

Analysis of variance table of mean squares, degrees of freedom, and F ratios for five independent variables on times-to-criterion of four concepts on a verbal board

Source	df	Mean Square	F ratio	p less than
Instructions (I)	1	8.42	NS	
Order of Type (OT)	1	1.41	NS	
Order of Difficulty (OJ)	1	.19	NS	
I × OT	1	1.71	NS	
I × OJ	1	9.64	NS	
OT × OJ	1	9.90	NS	
I × OT × OJ	1	6.37	NS	
Ss/I × OT × OJ	104	6.46		
Concept Type (T)	1	1310.20	228.61	.001
Concept Difficulty (J)	1	182.45	27.73	.01
T × J	1	27.06	4.20	.05
I × T	1	4.60	NS	
I × J	1	7.28	NS	
OT × T	1	4.74	NS	
OT × J	1	8.41	NS	
OJ × T	1	9.69	NS	
OJ × J	1	136.18	20.70	.01
I × OT × T	1	2.37	NS	
I × OT × J	1	4.98	NS	
I × OJ × T	1	.00	NS	
I × OJ × J	1	11.11	NS	
I × T × J	1	1.74	NS	
OT × OJ × T	1	9.87	NS	
OT × OJ × J	1	5.30	NS	
OT × T × J	1	.31	NS	
OJ × T × J	1	.00	NS	
I × OT × OJ × T	1	1.44	NS	
I × OT × OJ × J	1	.04	NS	
I × OT × T × J	1	11.46	NS	
I × OJ × T × J	1	2.95	NS	
OT × OJ × T × J	1	15.83	NS	
I × OT × OJ × T × J	1	7.48	NS	
Ss × I × OT × OJ × T	104	5.37		
Ss × I × OT × OJ × J	104	6.58		
Ss × I × OT × OJ × T × J	104	6.44		

cepts required only .7 more card choices than the J-2. When J-value was tested separately for both the training and selection concepts, the J-3 selection concept took significantly more card choices than the J-2 selection (J-3, 16.1; J-2, 12.1: $t = 3.51$, $p < .01$). But the J-2 training concept took more card choices than the J-3 training concept, though not significantly more (J-2, 19.3; J-3, 16.7: $t = 1.88$, t required = 1.96).

The two training concepts each required approximately 18.0 card choices and the two test selection concepts required 14.1 card choices.

The times-to-criterion on the training concepts were also analyzed. The mean time on the training concepts was 5.7 minutes. This was not significantly different from the mean time on the selection concepts, which was 5.5 minutes. The training concepts attained by Ss receiving the taped instructions took 5.4 minutes each and the time needed with the written instructions was 6.0 minutes each. The difference between taped and written was not significant. The first training concept took sig-

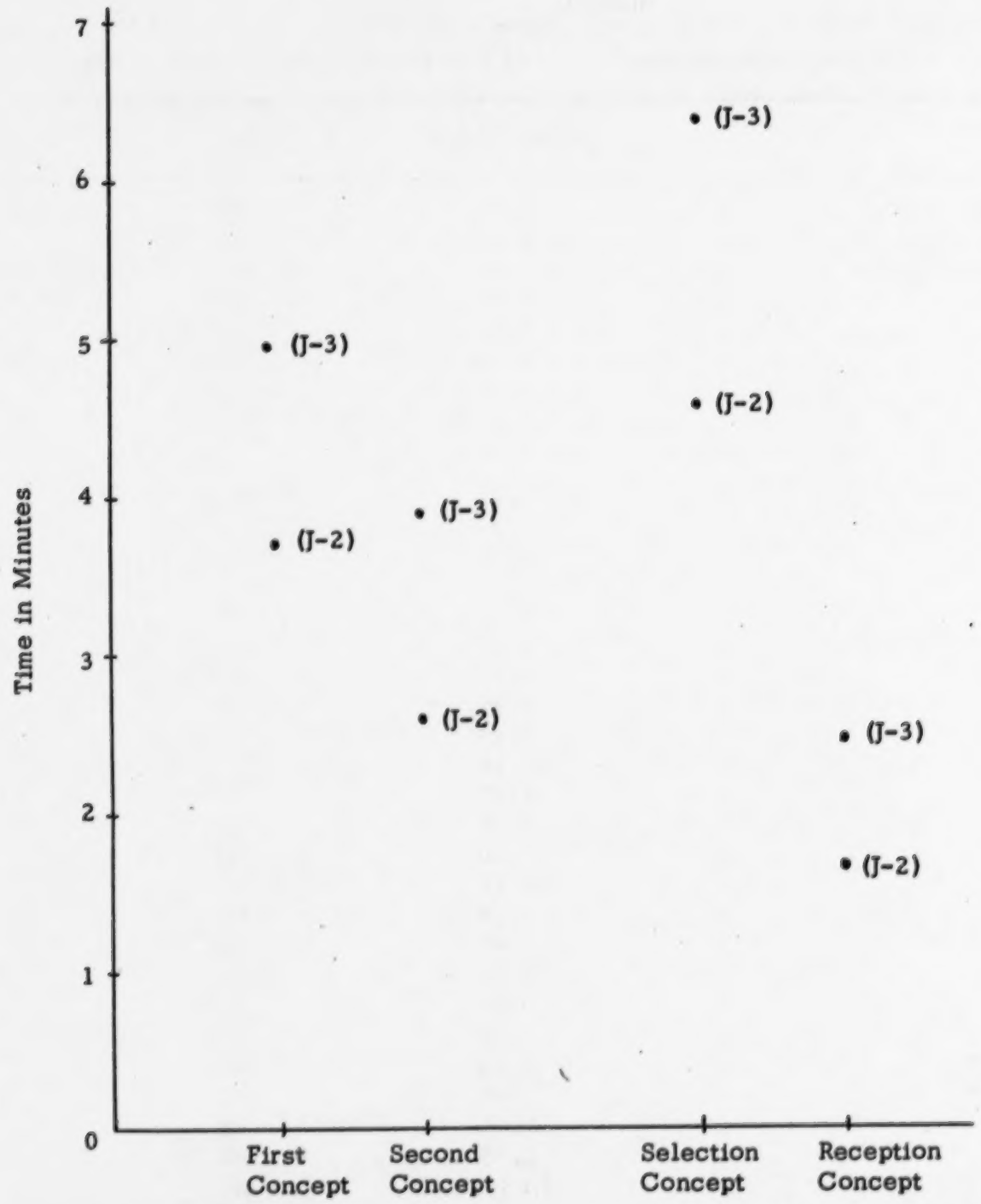

FIG. 2. Average times-to-criterion for the four test concepts. These have been separated into groups on the basis of J-value and ordinal position, and on the basis of J-value and type of concept.

nificantly longer than the second (6.26 minutes and 4.93 minutes, $t = 3.07$, $p < .01$).

The difference in time-to-criterion on the J-2 and J-3 training concepts was significant ($t = 2.15$, $p < .05$). The J-2 concept ONE LARGE averaged 6.1 minutes and the J-3 concept SOLID BORDERS, GREEN CIRCLES took 5.1 minutes. Females attained the concepts in an average of 5.5 minutes, males in 5.7 minutes. This difference was not significant. Because of previous sex by concept interactions (Archer, 1962), t tests were made on the time differences between the J-2 and J-3 training concepts for males and females separately. The scores of males yielded a t test value of .56. The scores of females yielded a t test value of 2.34, which was significant ($p < .05$). Though both males and females took longer to attain the J-2 training concept than the J-3 concept, the difference was largely due to the females doing exceptionally well on the J-3 concept and exceptionally poorly on the J-2. (See Fig. 3.)

The various means for times-to-criterion

and numbers of card choices are presented in Table 2.

Nineteen Ss were excused when they could not attain at least one of the training concepts or one of the selection or one of the reception concepts.

Two ANOVAs (with unweighted means due to unequal numbers in a cell) were done to test whether the E had any effect on the time-to-criterion scores. In both ANOVAs the F ratio for experimenter effect was less than unity and hence did not approach significance. The F ratios for the interaction of E × Concept, and for the interaction of E × Sex were also less than unity.

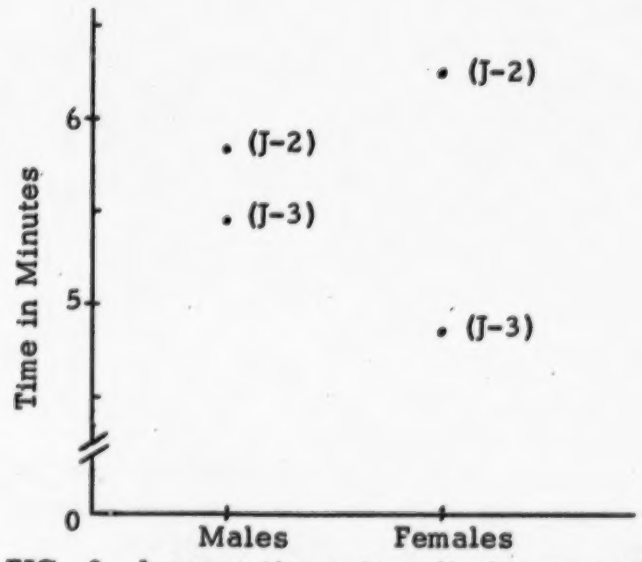

FIG. 3. Average times-to-criterion on each of the two training concepts for males and females.

TABLE 2

Summary table of mean times-to-criterion and mean numbers of card choices for the indicated groups.

Group	Training concept	Selection concept	Reception concept
Taped Instructions (56)[a]			
Time[b]	5.4	5.7	2.1
Card Choices	17.4	14.5	---
Written Instructions (56)			
Time	6.0	5.2	2.0
Card Choices	18.7	13.6	---
Taped and Written Combined (112)			
Time	5.7	5.5	1.9
Card Choices	18.0	14.1	---
Selection, Then Reception (56)			
Time	---	5.5	1.9
Card Choices	---	12.9	---
Reception, Then Selection (56)			
Time	---	5.4	2.2
Card Choices	---	15.5	---

	Training		Selection		Reception	
	J-3	J-2	J-3	J-2	J-3	J-2
Males (48)						
Time	5.5	5.8	6.4	4.7	2.7	1.6
Card Choices	19.3	19.9	16.8	13.5	---	---
Females (64)						
Time	4.9	6.2	6.3	4.5	2.3	1.8
Card Choices	14.8	18.9	15.5	11.0	---	---
Males and Females Combined (112)						
Time	5.1	6.1	6.4	4.6	2.5	1.7
Card Choices	16.7	19.3	16.1	12.1	---	---

[a] Indicates size of groups.

[b] Given in minutes.

IV
DISCUSSION

Forty-eight males and 64 females working individually attained two training concepts on a figural board and then four concepts on a verbal board. The boards had on them 64 cards in an ordered arrangement and were much like those used by Bruner et al. (1956). Concepts were combinations of two (J-2) or three (J-3) of the attribute values on the board. Two of the four concepts attained via the verbal board were of the same form as the two training concepts on the figural board, namely, the S had to choose cards to find which cards did or did not belong to the concept. The concepts in which Ss had to choose cards were called selection concepts. The other two concepts of the verbal board were called reception concepts, since in these, three or four YES and NO cards were marked and the S then attained the concept from these marked cards.

The instructions for the task were either given to the Ss by a tape recording or the Ss read them from a booklet. Four distinct sequences of concepts were developed and each sequence was used with six males and eight females.

The independent variables were: male or female; J-2 or J-3; selection or reception; J-2, J-3 or J-3, J-2; training, selection, reception or training, reception, selection; and taped instructions or written instructions. The dependent variables were time-to-criterion and number of card choices.

The specific questions about instructions, sex of the concept learner, J-value, reception and selection concepts, salience of concepts, and transfer of skills follow below. The discussion will be centered around each one of the questions in turn.

QUESTION 1. Is there a difference in performance between hearing the instructions for the task or reading them?

Instructions were included as a variable largely for the purpose of testing the feasibility of switching from the lengthy written instructions to the more efficient tape recording. The taped instructions took about 4 minutes less time than the written instructions, and they improved the experimental procedure since all Ss spent the same amount of time hearing the tape recording. With written instructions the time Ss needed to comprehend the instructions varied.

It was necessary, however, to test whether the taped instructions were as effective as the written instructions. A quick review of the findings will show that they were as effective. The average times needed to attain the training concepts were 5.4 and 6.0 minutes for the taped and written instructions, respectively. The average times on the four test concepts were 3.9 and 3.6 minutes for taped and written, respectively. Number of card choices for each concept for taped and written was 16.1 and 15.9, respectively. No effect of instructions or interaction including instructions was significant at or beyond the .05 level.

From this lack of difference we may conclude that whatever generality the experimentation had with written instructions is maintained with the taped instructions. Hearing the instructions is at least as effective as reading a similar set of instructions, and in this case, results in a saving of experimentation time.

QUESTION 2. Is there a difference in performance between males and females on this concept attainment task?

A check of the time-to-criterion on the test concepts revealed no significant sex differences. The .12 minute average difference implies that males and females were performing equally efficiently on the test concepts as far as time is concerned. On the training and selection concepts, however, males chose an average of 2.4 more cards per concept than the females. This difference was significant. Whether the greater number of card choices by males implies a faster rate of information loss for males or a better utilization of information

by females is uncertain. Many other hypotheses can be put forth to account for the greater number of card choices by males. For example, males may have a greater need for confirming instances, the implication being they used the additional card choices to make sure. Females may be better guessers or they may be better able to gain information from guesses.

An exercise that seemed more profitable was to look at specific concepts and see how these were handled by both sexes. Since Archer (1962) had found a sex difference with concepts involving size and form, the two training concepts on the figural board received immediate attention. Tests of significance on the time needed to attain the two training concepts showed that though males and females did about equally well on the concepts, the females had done significantly poorer on the concept ONE LARGE than on the concept SOLID BORDERS, GREEN CIRCLES. This was an astonishing result. For women, the "easy" J-2 concept had proved to be harder than the "hard" J-3. The number of card choices gave additional support and insight. Men made 19.9 and 19.3 card choices on the J-2 and J-3 training concepts, respectively; women, 18.9 and 14.8. Women attaining the J-2 concept required over four more card choices than they did on the J-3.

Why the J-2 concept took longer to attain than the J-3 will be discussed under "Question 5, Concept Salience." The question for the present is why did women react more to the difference between the J-2 and J-3 training concepts than the men, and why did women make fewer card choices.

In the Archer study (1962), in which men found concepts based on form easy to attain and women found them difficult, the results seem exactly at odds with the results of the present experiment. The concept ONE LARGE, in which form was irrelevant, should have been easier for females than for males according to Archer's findings, but it wasn't. The concept SOLID BORDERS, GREEN CIRCLES should have been harder for females, but the males found it more difficult, both in terms of time and number of card choices.

Something happens to females when they attain a concept in which form is a relevant attribute. In the Archer study (1962) they attained this type of concept more slowly than males, while in the present experiment they attained it more rapidly than males, and more rapidly than a concept not based on form. The Archer study and the present experiment had some methodological differences which point to some verbal factor operating. In the Archer study the Ss did not have to name the concepts but merely classified geometrical patterns correctly. In the present study, Ss had to mark the proper written attribute values.

Archer tried to explain his findings by assuming that the men in his study knew and used the form words better than the women did. But why should men have a monopoly on words relating to form when most word usage and vocabulary tests show women to be more verbal (Terman and Tyler, 1954; Tyler, 1956)? These same tests consistently show that males are better abstract reasoners than females are.

It seems that form is crucial; the concept must be couched in something concrete and easily verbalized. ONE LARGE has an incompleteness and abstractness about it that SOLID BORDERS, GREEN CIRCLES does not have. (Of the incorrect hypotheses given to the concept ONE LARGE, 48% included form as a relevant attribute.) If the greater abstract reasoning ability of the males did benefit them on the less concrete concept ONE LARGE, this would explain their doing approximately equally well on both training problems. Females, being slightly weaker than males on abstract ability but stronger on translating the figural signs on the board into verbal symbols, could be expected to do slightly better than males, and especially so on a concrete concept.

Why were there no sex differences on the verbal materials? Perhaps marking the same words which appear on the cards requires much less verbal facility than translating figures into words. Perhaps the male Es had some effect on females which only showed up with the figural material, but this does not appear to be the case since the data showed no such interaction. An experiment to specifically investigate the sex differences uncovered is needed. What exactly is the interaction of sex of S with the kind of concept being attained?

QUESTION 3. Are concepts with three relevant attributes more difficult to attain than concepts with two relevant attributes?

As far as the concepts on the Ed Psych board are concerned, the answer to this can be a resounding yes. J-2 concepts were attained in an average of 1.3 minutes less time than the J-3. The J-2 selection concept required 12.1 card choices and the J-3 required 16.1 card choices, a significant difference. In addition, the interaction of J-value by concept type showed that J-3 selection concepts were relatively more difficult than J-3 reception concepts.

A closer look at what constitutes a J-2 and

J-3 concept in this experiment reveals that the preceding paragraph says more than meets the eye. A J-2 concept has two relevant attributes, to be sure, but it also has four irrelevant attributes. In the same way, a J-3 concept has three relevant attributes and three irrelevant attributes. Relevant attributes are added at the expense of the irrelevant and vice-versa. Though other experiments have shown consistently that rate of concept learning is a decreasing function of increasing numbers of relevant attributes, similar experiments have shown just as consistently that rate of attainment is a decreasing function of increasing numbers of irrelevant attributes.

In the present experiment the confounding of the number of relevant and irrelevant attributes has given a direct test of which of these two effects is more powerful. From the knowledge gained in experimentation cited in Chapter II, it is possible to make some useful deductions when this knowledge is applied to the present results. Below is a plot of the average time-to-criterion of the J-2 and J-3 concepts. Fig. 4a shows time as a function of relevant information and Fig. 4b shows time (the same two points as in 4a) as a function of irrelevant information. The broken lines denote probable functions. The probable functions are approximately linear as was found by Walker and Bourne (1961), Brown and Archer (1956), Gregg (1954), Bourne (1957), and Shepard, Hovland, and Jenkins (1961).

Additional points need to be added to the plots to determine the probable functions more exactly, and such an experiment is already proposed. As a preliminary guess on the basis of the information obtained so far, it seems that one bit of relevant information adds more to the complexity of the task than one bit of irrelevant information. In other words, the relevant information function has a steeper slope than the irrelevant. This is shown graphically in Fig. 4.

An immediate question at this point is why wasn't the J-2 training concept on the figural

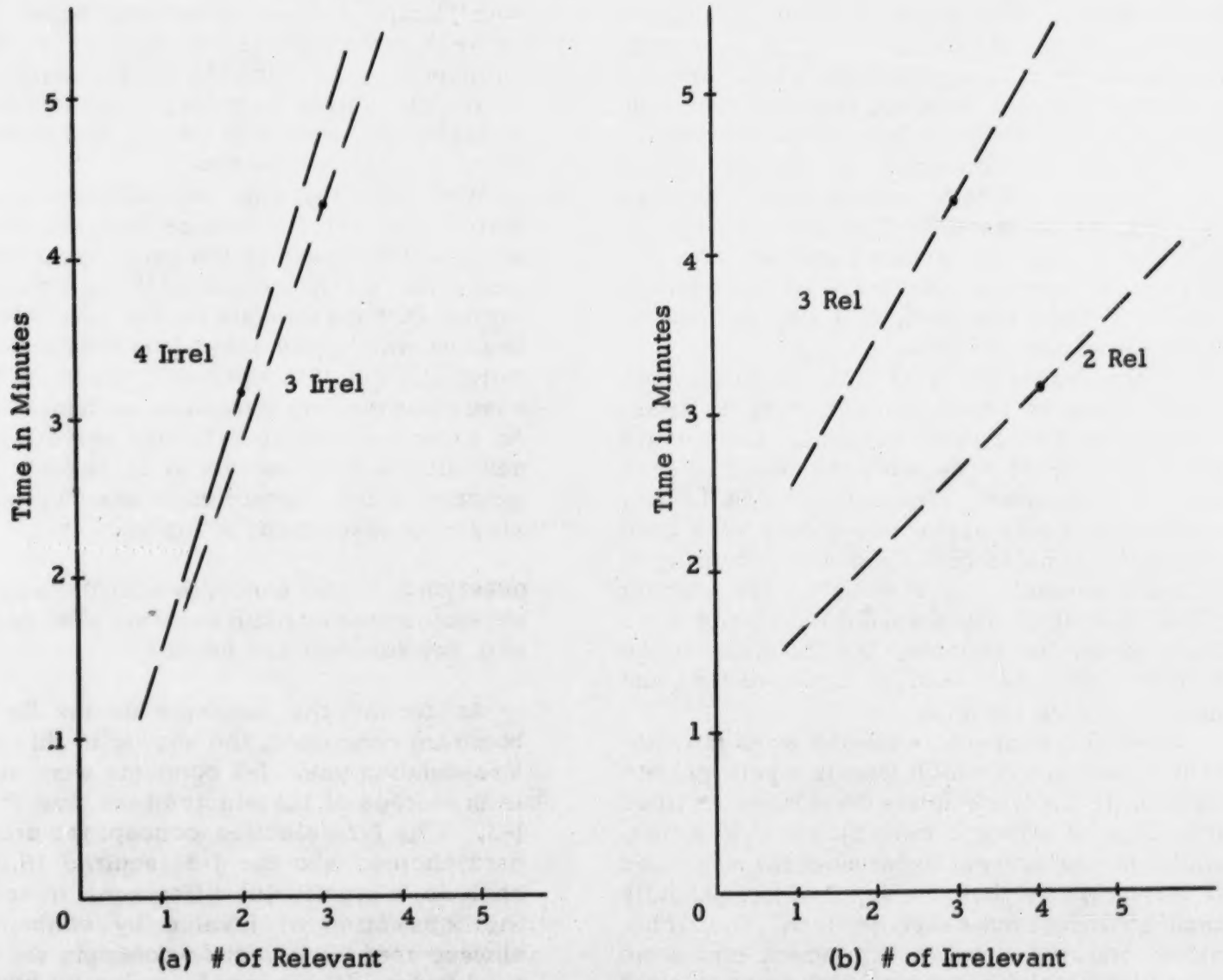

FIG. 4. Difficulty as a function of number of relevant and irrelevant attributes.

board easier than the J-3 training concept since these two also had the different amounts of relevant information? The only answer seems to be that another factor was outweighing the effect of the relevant and irrelevant information; a factor which influenced the attainment of concepts on the figural board but not those attained from the Ed Psych board. For the moment, it will be sufficient to say that an attribute such as "Teacher Method" seems to be as important and equivalent subjectively as the attribute "Evaluation" which seems to be as important subjectively as "Domain" which seems, etc. But "Color of Figure" does not seem equivalent to "Shape of Figure," and "Number of Borders" seems even less equivalent. The attributes of the figural board suffer from a defect which has been noted before (Wallace, 1964) and which is here termed as differing levels of attribute "salience." This effect is discussed below under Question 5.

QUESTION 4. Will a concept for which minimal but sufficient information is given (reception) be easier to attain than a concept for which the S must obtain information for himself?

The answer to this is clearly yes. The ANOVA showed that the mean time difference between reception and selection concepts, 2 minutes and 5.5 minutes respectively, had the highest F ratios of any analysis made and was significant at the .001 level. This result agrees with results obtained by Huttenlocher (1962), Kates and Yudin (1964), Hovland and Weiss (1953), and Bourne (1963). Huttenlocher had shown that selecting test examples and deciding which attributes to check added a complicating factor to concept learning. In the present experiment the selection concepts, in which the S had to choose cards, may have been as hard as they were, partly because of the additional complexity of card choosing and decision making which the reception concepts did not require.

In addition, the memory requirements of the two types of concepts were obviously different, and this, as Cahill and Hovland (1960) showed, can have a significant effect. Cahill and Hovland's experiment demonstrated that memory errors increase as a S must remember more and more cards in a successive presentation condition.

In the interest of being fair to this topic it might be well to add that it is surprising that the reception concepts took so long. In the reception concepts Ss needed an average time of 2 minutes to process the information from 3.5 cards and in the selection concepts Ss needed 5.5 minutes to process 14.1 cards. Clearly, there was a slower rate of card processing in the reception concepts.

On the other hand the 14.1 card choices of the selection concepts (over twice as many card choices as the six minimally needed) shows that many Ss were not using all the information contained in each card choice and that much of the information of the later card choices was redundant. The large average number of card choices with its resultant redundant information again implicates memory as an important aspect of the concept situation. The repetition of a card choice or the retesting of an attribute is perhaps the easiest way for Ss to overcome the handicap of forgotten information.

QUESTION 5. What is the effect of the dominance or salience level of certain attributes?

We have made the assumption that the attributes of the verbal board are equivalent. That is, "Teacher Method" does not have a greater level of obviousness as an attribute than does "Subject Area" or "Learning Outcome" or any of the others. The results with the verbal board all seem clear and unequivocal. On the verbal board males and females do about equally well. On the verbal board J-3 concepts which contain three relevant attributes are harder to attain than J-2 concepts. All the significant and nonsignificant results obtained with the verbal board were easy to explain and followed from hypotheses already at hand. Indeed, the results were expected and several hypotheses were confirmed, and from this the experiment might have been considered a success.

We also assumed that the attributes of the figural board were equivalent. That is, the "Continuity of Borders" is approximately as dominant as "Number of Figures" and as salient as "Shape" and "Size of Figures." The results with the figural board were strange and unexpected. The J-3 concept, which contained three relevant attributes, was easier to attain than the J-2 concept. Females attained one of the concepts more quickly and with fewer card choices than men did. The fact that these results could not be conveniently explained caused the assumption of equivalent attributes to be questioned.

There was a growing body of evidence which suggested that the attributes of the figural board were far from equivalent. Archer (1962) had found size and form nonequivalent. Heidbreder (1948) had shown form easier than num-

ber. Wallace (1964) had ranked number-color concepts far less dominant than color-form concepts. The evidence given by Wallace, Heidbreder, and Archer made it logical to reason that the number-size concept, ONE LARGE, might be considerably less salient than SOLID BORDERS, GREEN CIRCLES, which included color and form attributes.

The number-size concept was indeed harder to attain than the other. The J-2 concept ONE LARGE required significantly more time to attain than the J-3 concept SOLID BORDERS, GREEN CIRCLES. In addition to the 1 minute time difference, the J-2 concept also required 2.6 more card choices which was nearly significant.

A cursory look at the incorrect hypotheses offered by Ss will illuminate what happened. Of the 338 incorrect hypotheses offered by 112 Ss for the J-2 concept, 48% included the irrelevant attribute "Shape of Figure." This compares to 40% for "Number of Borders," 20% for "Continuity of Borders," and 33% for "Color of Figures," all of which were irrelevant. The attribute "Number of Borders" may have the high percentage because it was the first attribute on the concept slip on which the Ss marked the attribute values. Of the 232 incorrect hypotheses offered for the J-3 concept, 44%, 36%, and 27% included the irrelevant attributes "Number of Borders," "Number of Figures," and "Size of Figures," respectively. Again "Number of Borders" is high, possibly because it was first on the list.

In numerical terms, "Shape of Figures" was listed as a relevant attribute 163 times when it actually wasn't relevant. This happened with "Color of Figures" 109 times, "Border Continuity" 70 times, "Number of Figures" 86 times, and "Size of Figures" 61 times. Note that the attributes are clearly not used equally often by Ss.

The saliance value of various attributes must be determined and made approximately equal if any generalizations are to be made about number of relevant and irrelevant attributes. There is some evidence to show that the sex of the concept learner interacts with the salience of attributes. It is even more probable that the effect of attribute salience would be even more pronounced in studies with children and adolescents. Salience must be an important determiner of concept learning ease, for in the present situation a J-3 concept was learned more rapidly, and with fewer card choices and fewer false hypotheses than was a J-2 concept. The J-3 concept was more salient than the J-2 and this significantly affected the results in spite of the fact that the J-3 concept had one bit more "information reduced" than the J-2 concept.

The question about salience of attributes cannot be answered well on the basis of just this experiment, and indeed the reasoning used here is entirely after the fact. Some measure of salience is needed. All one can say for the present is that salience does have an effect. Form seems to be a very salient attribute and therefore very crucial. The other five attributes of the present experiment do not have clearly comprehendable effects and they certainly don't appear to be equivalent. Further experimentation should yield some answers about the comparability of attributes.

QUESTION 6. Will practice on one type of concept aid in the attainment of another?

A review of the results of the present study seems in order and the facts which relate to transfer are as follows: The Ss attaining concepts in the order training-selection-reception did not differ on average time-to-criterion on the four test concepts from the Ss attaining concepts in the order training-reception-selection. Ss attaining J-2 concepts and then J-3 did not differ on average time-to-criterion of the four test concepts from those Ss attaining J-3 and then J-2 concepts. Ss improved significantly in time-to-criterion from the first concept to the second concept in each set of two selection and two reception concepts, and in the set of two training concepts. The time-to-criterion on selection concepts did not differ between the group which received selection and then reception concepts and the group which received reception, then selection concepts, nor did the time-to-criterion of the reception concepts differ for these two groups.

Number of card choices made on the selection concepts did vary for these two groups. The reception, then selection group made more card choices than the selection, then reception group. The training concepts required an average of 18 card choices and the selection concepts required 14.1 card choices.

The time-to-criterion on the training concepts was 5.7 minutes which compares to the 5.5 minutes average time taken by Ss on the selection concepts. This difference was not significant; it may still show transfer of skills since concepts on a verbal board normally take more time than those on a figural board (Ramsay, 1965).

As a short summary of the results just reviewed it might be said that time-to-criterion

showed there was ample improvement within each set of two concepts. Number of card choices decreased from the training to the selection concepts. The interpolation of reception concepts between the training and selection concepts attenuated the decrease somewhat.

There are basically two skills that Ss could develop and transfer in the present concept learning situation. These skills are the selection of cards and the processing of information given by successive cards. Both skills are needed in the training and selection concepts. Only information processing is required in the reception concepts.

The improvement from the first reception concept to the second may then be viewed as due to better and faster information processing. It is not clear whether the improvement within the sets of training and selection concepts is due to better information processing or better card choosing, or both. The fact that interpolation of reception concepts before the selection results in more card choices being made than if the selection concepts immediately followed the training tasks points to wise card choosing as at least partially responsible for the improvement.

Since the training concepts always preceded the selection and reception concepts, the transfer that might occur from training to selection and from training to reception cannot be measured. It can be seen that the training plus selection concepts gave no more transferable skills than the training concepts alone, and that training plus reception helped Ss no more on the selection than the training concepts alone did.

However, there is some generality in the effects of J-value and transfer. Learning a J-2 concept provides skills which can be used when attaining a J-3 concept. These skills also transfer when going from a J-3 to a J-2 concept.

CONCLUDING DISCUSSION AND FINAL SUMMARY

Male and female human Ss participated in an experiment in which they had to attain a series of six concepts. The concepts consisted of a combination of two or three relevant attributes from among the six attributes on the display boards which were of the type used by Bruner et al. (1956). Ss first attained the two concepts ONE LARGE and SOLID BORDERS, GREEN CIRCLES by selecting cards to see whether the card was or was not an instance of the concept. After two training concepts on a figural board, a verbal Ed Psych board was used. Ss attained four concepts using it; two concepts were again of the card selection type and the other two required only that the S determine the concept from cards marked YES or NO.

The time needed to attain each concept and the number of card choices were the dependent measures. A total of 112 Ss participated in the experiment; 64 of these were females, and 48 were males. The design of the experiment was such that the effects of sex of S, number of relevant and irrelevant attributes, type of instructions (tape recorded or written), and order of concepts could be determined. Several measures of transfer were also obtained.

The time-to-criterion scores on the concepts of the verbal board showed that selection concepts were much more difficult than reception concepts, and that J-2 concepts were easier than J-3 concepts. Sex, instructions, and concept order had no significant effect. Only two of the 26 interactions were significant. One interaction demonstrated the fact that Ss improved from the first to the second concept in the set of selection concepts and in the set of reception concepts. The other resulted from the J-3 selection concept being relatively more difficult than the J-3 reception.

The time-to-criterion scores on the two training concepts showed surprisingly that the J-3 concept was easier than the J-2. Again, instructions and concept order were not significant, but females attained the J-3 concept much more easily than the J-2.

Number of card choices on the training and selection concepts showed that females had chosen less cards than males. This was primarily due to the J-3 training concept in which females averaged four less card choices than males.

It was hypothesized that the unusual results which the training concepts gave was due to the different salience levels of the attributes of the figural board. The salience levels somehow interacted with the sex of the S. A small number of previous experiments had also detected the effects of salience level, and one experimenter found a salience by sex interaction. The problem of differing levels of attribute salience is being further investigated.

The results of the experiment generally confirmed and amplified the results other experimentation had produced. The function of number of relevant and irrelevant attributes was extremely interesting and the problem of further determination of the relative importance of both relevant and irrelevant information seems

especially worthwhile. Perhaps a combination of "information reduced," "noise," and "salience" can form the basis of a theory for predicting the complexity of conjunctive concepts.

Although the results of the present experiment were obtained from a highly structured situation, there is evidence that the regularities which were found apply to entire classes of concept attainment tasks including the discrimination learning arrangements of Archer and Bourne, and the predominantly verbal learning situations used by Hull, and especially the category learning experiments of Bruner, Goodnow, and Austin.

APPENDIX

These tape recorded instructions for the figural board were given to half the Ss at the start of the experiment:

> This experiment is concerned with how people form concepts. You're going to have an opportunity to work several problems in concept formation.
>
> Here is a display of cards with various figures, borders, and colors. Let's examine it more carefully. Card #15 has one border; card #62 has 2 borders; card #15 has a solid border; card #21 has a broken border; card #15 has one circle; card #69 has 2 circles; card #15 is a circle; card #77 is an ellipse; card #15 is a red circle; card #18 is a green circle; card #15 has a large circle; card #16 is a small circle. You notice that each card is different from the rest. However, there are a number of ways the cards may be grouped so that the cards have common features. For example, all the cards having circles may be grouped together. Point out four cards that belong to the concept CIRCLE. (E verifies choices.) That's fine.
>
> We might also group all the cards with red ellipses. Show me four cards which belong to the concept RED ELLIPSES. (E again verifies and makes corrections, if necessary.) That's very good. When I said all the cards with red ellipses could be grouped together, I was stating a concept for classifying the display.
>
> In this experiment, your job is to find out what concepts I have used for selecting a series of similar cards. The procedure is as follows: at the beginning of each problem I will show you one card which belongs to the concept; then you are to select other cards which you want to test for group membership. You may select a card for testing by pointing to it and reading off the number which you see right below it. Each time you test a card, I will tell you if it is a member of the concept that I have in mind. As you find out which cards do and do not belong to the concept, you can ascertain what the concept is. Whenever you think you know the concept, stop and tell me. In order to avoid confusion in stating the concepts, here is a form on which you check the words which describe the concept. For example, check the concept SOLID BORDERS, GREEN ELLIPSES. That's fine. Let's check another now: TWO BORDERS, ONE FIGURE. That's good. If you have stated the concepts correctly, the problem is over. If you have made a mistake, I'll simply say, "Not correct" and you will continue testing more cards until you feel you know the concept. You may state as many concepts as you like. The job, however, is to get the correct concept as quickly as possible. Do you have any questions?

After the two training tasks, the instructions for the Ed Psych board were given via the tape recording as follows:

> You have just completed two concepts on the figural board. The next concepts are similar to the ones just completed and they will be done on what we call our Ed Psych board.
>
> First, let us look at the blue slips to determine what is on the Ed Psych board. Notice that we have 2 instances of teacher method, namely: to lecture, to demonstrate; 2 instances of evaluation—objective, subjective; 2 instances of domains—cognitive, psychomotor; 2 instances of subject area—natural science, social science; 2 instances of learning outcome—fact, motor skill; 2 instances of motivation—extrinsic, intrinsic. Now examine the large board.
>
> Let us examine cards that also have these 12 things on them. Card #47 is an instance of to lecture; card #48 - to demonstrate;

card #47 is an instance of objective evaluation; card #59 - of subjective evaluation; card #47 contains an instance of cognitive domain; card #06 - psychomotor domain; card #47 - an instance of natural science; card #27 - an instance of social science; card #47 - an instance of fact; card #69 - an instance of motor skill; card #47 - an instance of extrinsic motivation; card #57 - an instance of intrinsic motivation.

We mark the concept on this sheet just as we did previously. You mark the concept OBJECTIVE EVALUATION, PSYCHOMOTOR DOMAIN, EXTRINSIC MOTIVATION. Now mark a second concept TO LECTURE, INTRINSIC MOTIVATION. That's fine. Now pick out 4 cards that belong to the concept TO LECTURE, INTRINSIC MOTIVATION. All right. Now find 4 cards that don't belong to the concept. This is good.

Your job will be to attain 4 concepts using the specific instructions that the experimenter now gives you.

The other half of the 112 Ss were given written instructions at the start of the experiment which were as follows:

This experiment is concerned with how people attain concepts. You are going to have an opportunity to work several exercises in concept attainment. The exercises will be performed by using the board with 64 cards on it, located directly in front of you. Every card on the board is different from every other card. However, all of the cards have six basic dimensions.

Consider the number of borders on each card. Note that all the cards on the board have either one or two borders. (Examples)

Border Number is one of the dimensions of the cards, taking the value One Border or Two Borders.

Similarly, Border Continuity is another dimension on the cards. Each card has either Broken Borders or Solid Borders. (Examples)

Figure Number is another dimension on the cards. Each card has in the lower left corner either One or Two figures. (Examples)

Figure Shape is another dimension of the cards. The figure or figures on the cards take the shape of either Circle or Ellipse. (Examples)

Figure Color is another dimension on the cards. The figures are either Red or Green. (Examples)

Finally, Figure Size is a dimension on the cards. Each figure, in addition to being Red or Green, One or Two, and Circle or Ellipse is either Large or Small.

Thus, all of the cards contain six dimensions and each of the dimensions can take one of two values. Two of the dimensions deal with the borders on the cards. One of these dimensions is Border Number, One or Two; the other is Border Continuity which takes the values Broken or Solid. The other four dimensions deal with the figures on the cards. These dimensions and their respective values are: Figure Number, One or Two; Figure Size, Large or Small; Figure Color, Red or Green; and Figure Shape, Circle or Ellipse.

Every card on the board is different from every other card in at least one of the values just described. For example, consider the two cards on the next page, at the top. (Examples) The card on the left above may be described as having one solid border with one large red elliptical figure. The card on the right has two solid borders with one large green elliptical figure. The cards are different with respect to their border number and figure color.

Take a moment and describe the card below in terms of specific values of the dimensions Border Number, Border Continuity, Figure Number, Figure Size, Figure Color and Figure Shape. (Example) You should have described this card as having two broken borders with two small red elliptical figures.

The word "Concept" has a rather abstract meaning; in this experiment we will use the word "concept" in a very practical and specialized sense. A concept, as we will use it, means a particular combination of values of the six dimensions we have described. For example, ONE BORDER with TWO RED CIRCLES is a concept as we have defined it. Certain cards on the board "belong" to this concept and certain cards do not. Specifically, all the cards which have one border with two red circles belong to this concept

and all the cards that are lacking in one or more of these four values do not belong to the concept. For example, consider the following three cards. (Examples) These three cards can be grouped under the concept TWO RED FIGURES. (Example) The card above does not belong to this concept since it lacks the value Red. The three cards below can be grouped under the concept, TWO BORDERS with TWO CIRCULAR figures. (Example) You determine the concept under which the three cards below can be grouped. (Examples) You should have decided that the concept to which the three cards belong is SMALL RED FIGURE/S. The term "figure/s" implies that there may be either one or two figures. Which of the cards below belong to the concept ONE BORDER with RED ELLIPTICAL FIGURE/S? (Examples) The first two cards belong to the concept. The third card does not. Can you tell why? It is because the third card has Two borders.

Cards which belong to a particular concept we will call "yes" cards. Cards which do not belong to a particular concept we will call "no" cards. For example at the bottom of the preceding page, the first two cards were "yes" cards and the third card was a "no" card for the concept ONE BORDER with RED ELLIPTICAL FIGURE/S.

In this experiment your job is to determine a concept that the experimenter has in mind. To begin, the experimenter will point out to you one card which belongs to the concept. This card will be called the "focus card." Thus, a particular combination of one or more of the values on the focus card will make up the concept. Suppose the card below was a focus card. (Example) The values contained on this card are One Broken border with Two Red Circular figures; and some combination of one or more of these values makes up the concept you would attain.

In order to attain the concept you will choose other cards on the board. Do this by reading off the number underneath the card you have chosen. If the card you have chosen belongs to the concept, the experimenter will say "yes." If the card you have chosen does not belong to the concept, the experimenter will say "no." As you find which cards do and do not belong to the concept you can ascertain the concept. When you think you know the concept take a form like the one shown below and check off those values which you think make up the concept. (Example of form)

For example, the concept, TWO BORDERS with RED FIGURES would be marked in the following manner: (Example) Another concept might be, TWO BROKEN BORDERS with SMALL CIRCULAR FIGURE/S. It would be marked in the following manner: (Example) When you think you know the concept, check off the values on a form and give it to the experimenter. He will read it back to you so there is no misunderstanding. If your concept is correct, the task is completed. If it is not, the experimenter will say "not correct" and you will continue selecting cards until you again think you know the concept. You may present as many concepts as you like. The job is to attain the concept as quickly as possible. Are there any questions?

After the two training concepts on the figural board these written instructions for the Ed Psych board were read by the S:

You have just completed a training exercise on the figural board. The next problems which are similar to the ones just completed will be done on what we call the Ed Psych board. Consider for a moment some of the detail concerned with this board.

The new board has six basic dimensions similar to those of the figural board. These dimensions are: 1. Teacher Method, 2. Evaluation, 3. Domain, 4. Subject Area, 5. Learning Outcome, 6. Motivation.

As previously there are always two:

1. Teacher Method	To Lecture	To Demonstrate
2. Evaluation	Objective	Subjective
3. Domains	Cognitive	Psychomotor
4. Subject Areas	Natural Science	Social Science
5. Learning Outcomes	Facts	Motor Skills
6. Motivation	Extrinsic	Intrinsic

The following card (Example) is marked as follows: (Example of form properly marked.) These two cards (Examples) belong to the concept COGNITIVE DOMAIN, NATURAL SCIENCE and EXTRINSIC. You take a blue slip and mark this concept for the examiner.

You will have four problems to solve. These four problems represent two different kinds

of tasks. One task is exactly like the training problem except we will use the Ed Psych board. The other task requires a page of directions but also uses the Ed Psych board. These directions will be given to you just prior to having that task.

Do you have any questions ?

Just prior to the selection concepts (sequences 1 and 2) the E said, "In these next concepts you must test cards as you did on the figural board."

Just prior to the reception concepts (sequences 3 and 4) all Ss read this explanation:

In these next problems, your job will be to determine a concept from information presented. The procedure will be as follows: I shall give you a focus card and several other cards which present enough information for you to attain a concept. I shall specify the focus card, yes card (or cards) and no card (or cards). The following markers will be used. F—focus card, Y—yes card, and N—no card. When the markers are arranged correctly, you will process the information presented to determine the concept. When you think you know the concept, mark it on the slip as in the previous problem. If your concept is correct, the problem is over. If not, I shall say "not correct" and you will again examine the cards until you think you know the concept. Your job is to attain the correct concept as rapidly as possible.

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